Using a Remote Telescope in an Undergraduate Astronomy Course

Bryan Penprase - Pomona College and Yale-NUS College

- Overview of Remotely Operable Telescopes from N. Hemisphere
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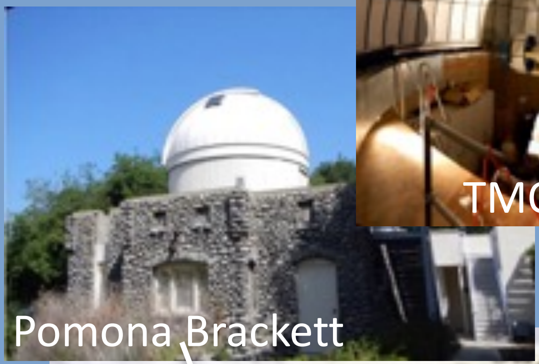
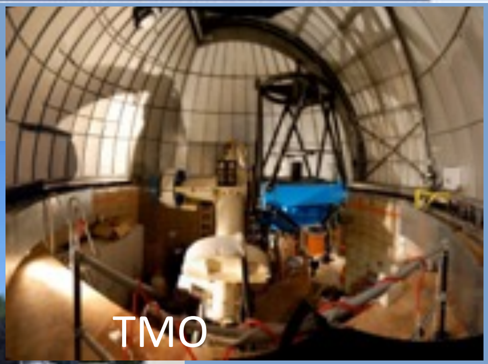
- Next Steps - How can we each contribute to Global Astronomy Course? (discussion)

GROWTH

Global Relay of Observatories Watching Transients Happen



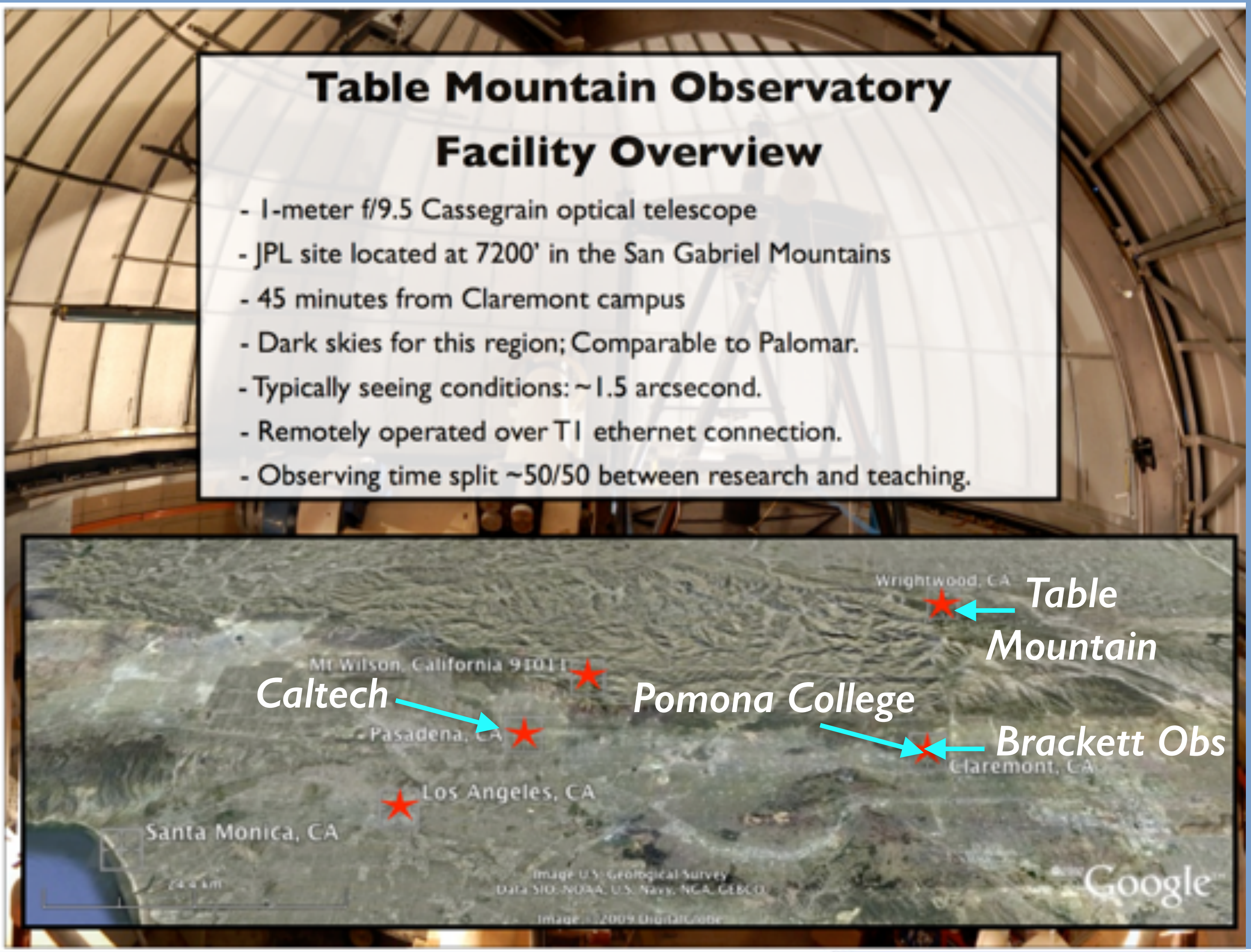


Telescopes for Undergraduate Research Projects

Pomona College Telescopes Overview

Bryan Penprase, Pomona College

From Choi, et al, 2010, IFA AO workshop



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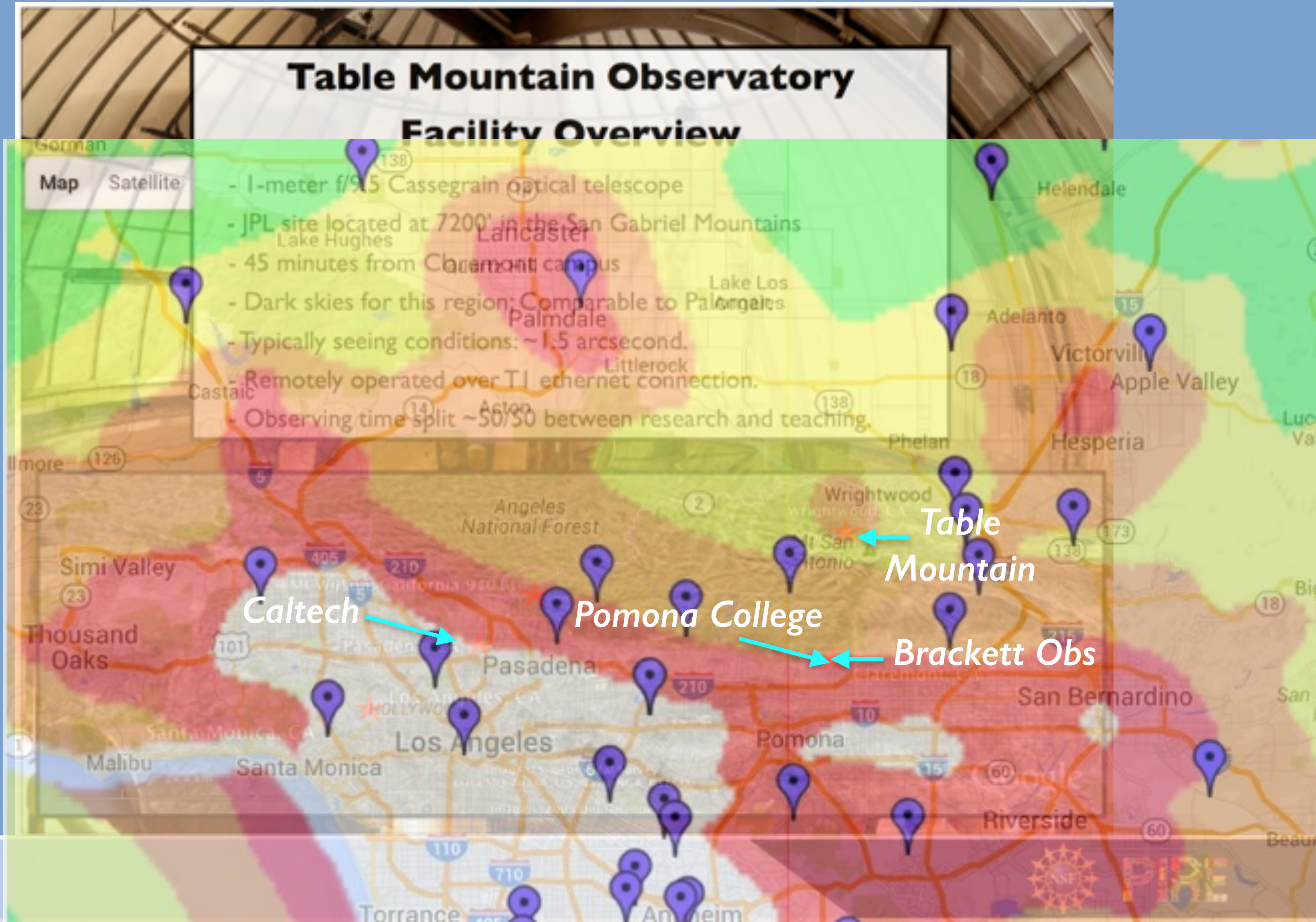

Pomona College Telescopes Overview

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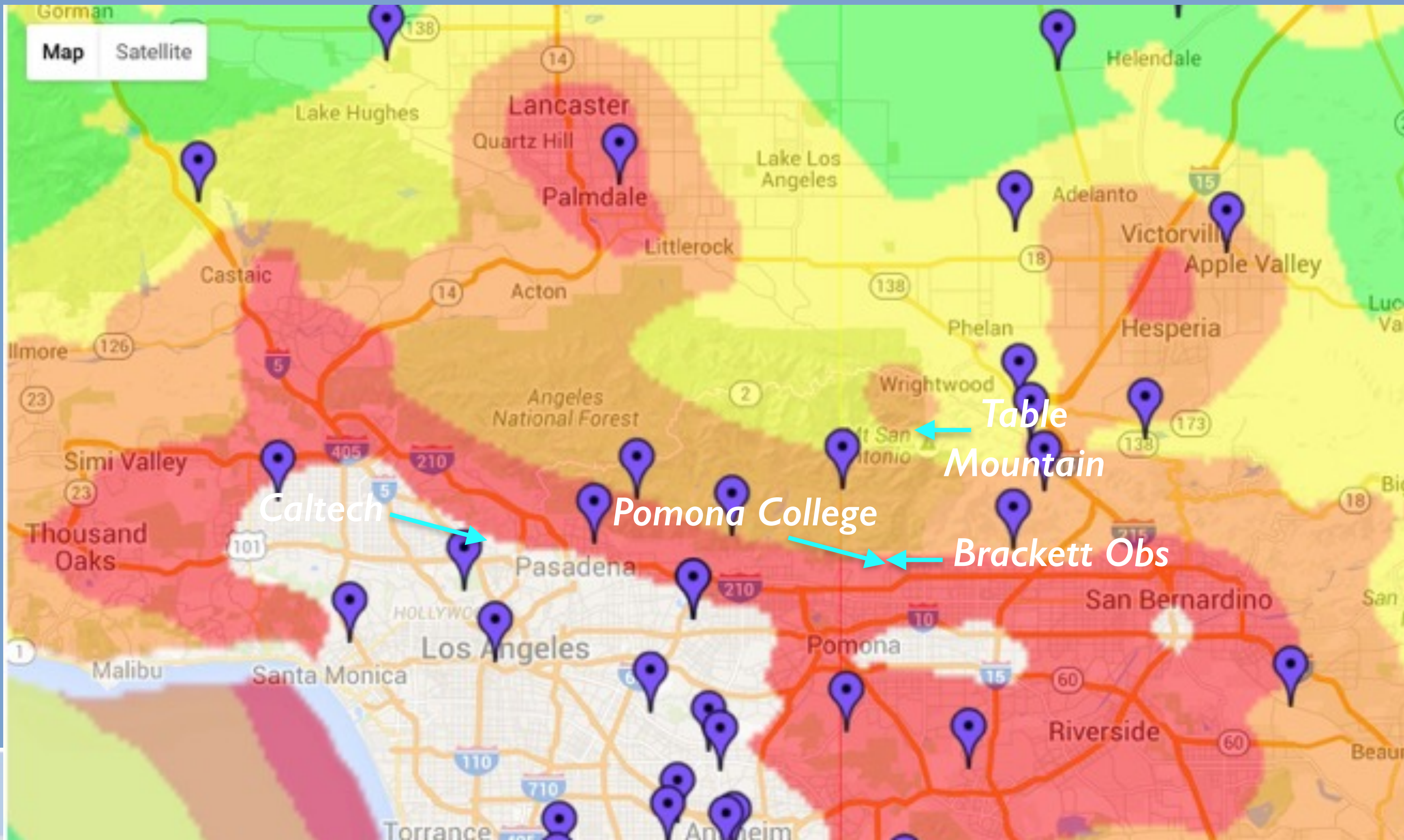
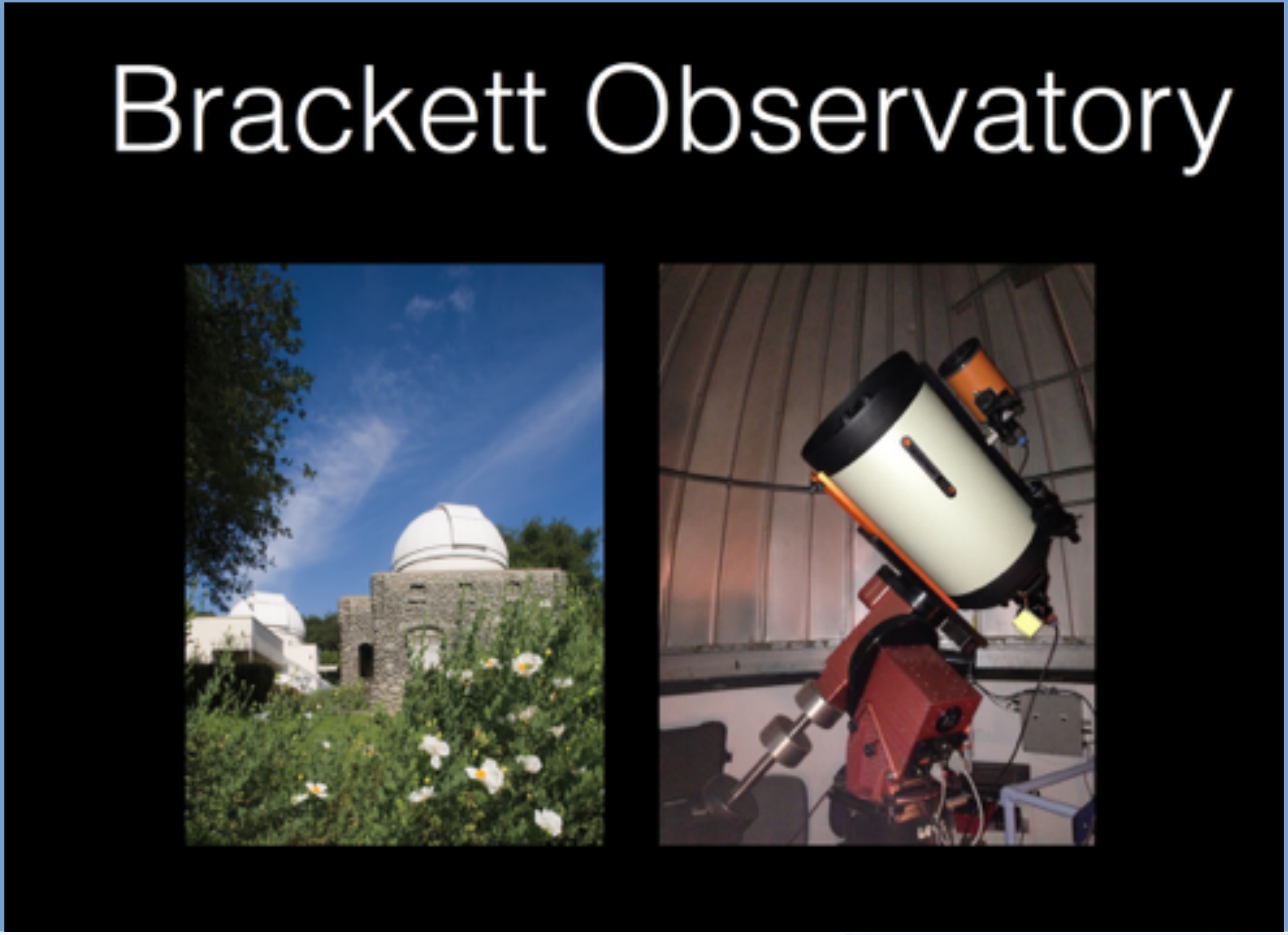
From Choi, et al, 2010, IFA AO workshop



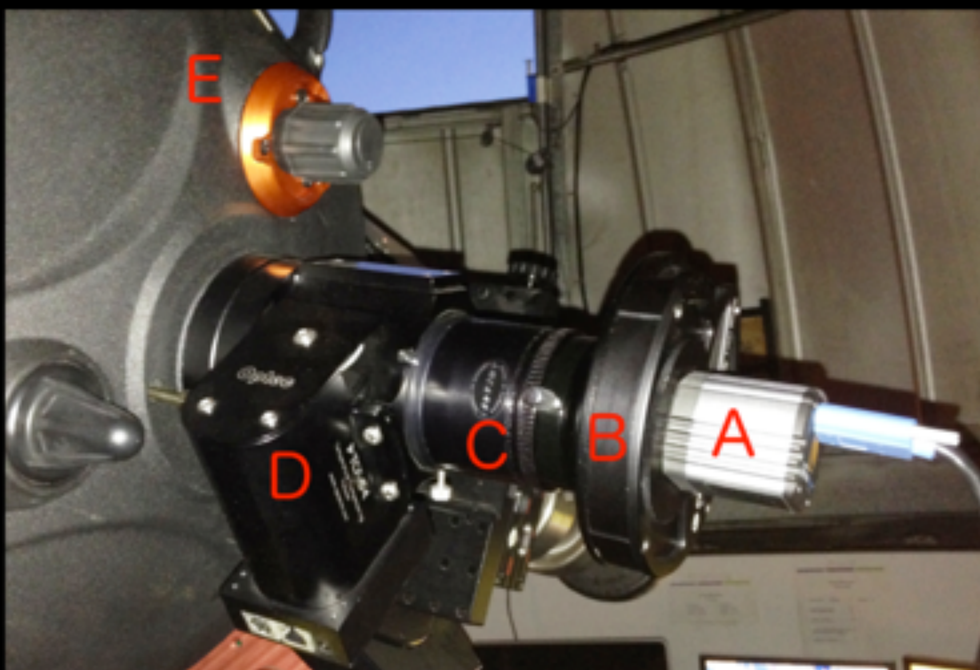
Pomona College Telescopes Overview

Bryan Penprase, Pomona College

Located at Pomona College in Claremont, CA - 2x14” (0.3-meter) telescopes, with computer control



niche: solar system (bright) objects; high resolution imaging "Lucky" imaging system

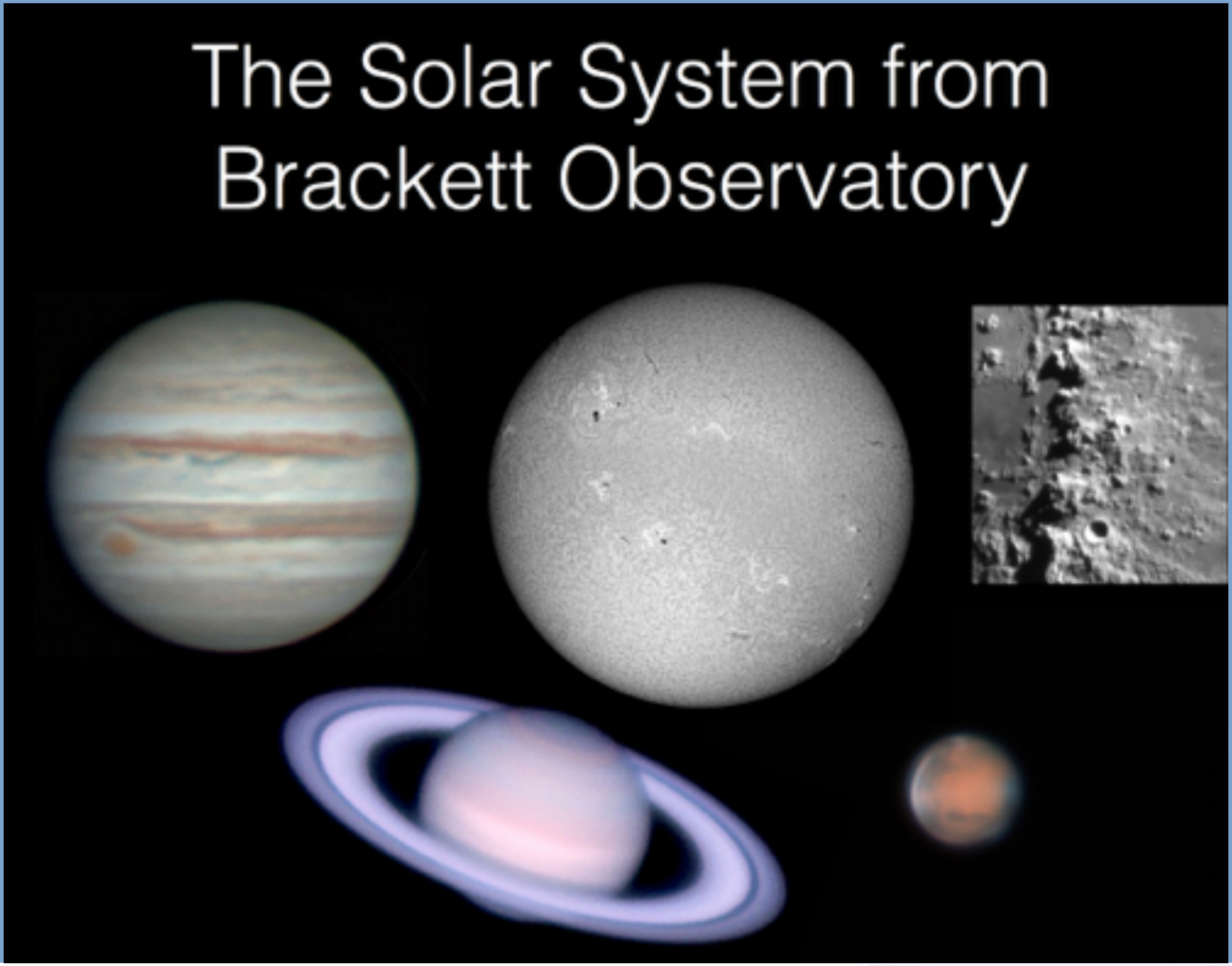


Letter	Component
A	Skyris Camera
B	Skyris Filter Wheel
C	Antares 1.6x Barlow Lens
D	Optec TCF-S Focuser
E	Celestron C14

Pomona College Telescopes Overview

Bryan Penprase, Pomona College

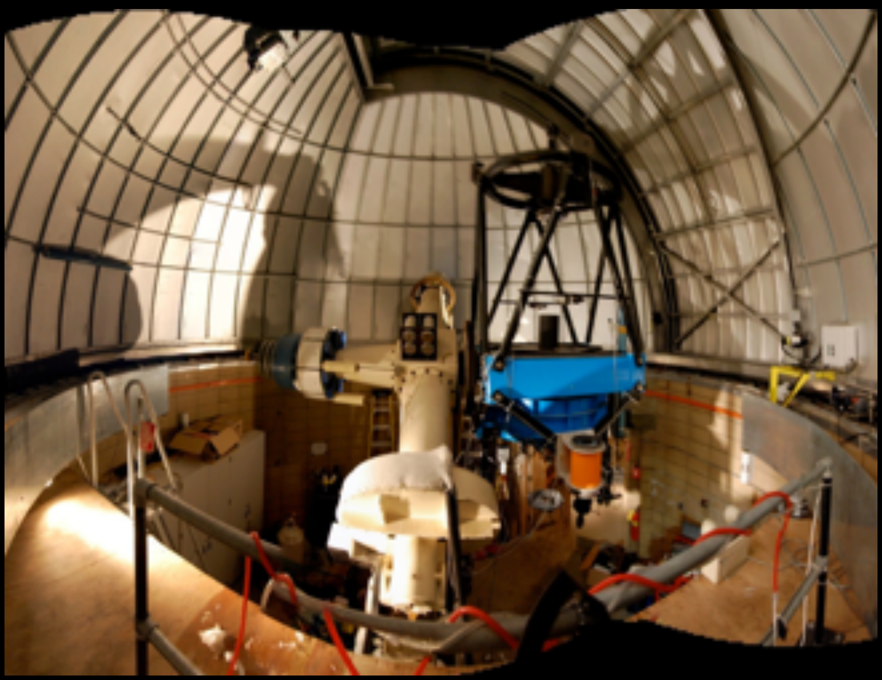
all images taken by Franklin Marsh (PO '18) at Brackett Observatory



Pomona College Telescopes Overview

Bryan Penprase, Pomona College

Table Mountain Observatory



Pomona College Telescopes Overview

Bryan Penprase, Pomona College

From Choi, et al, 2010, IFA AO workshop

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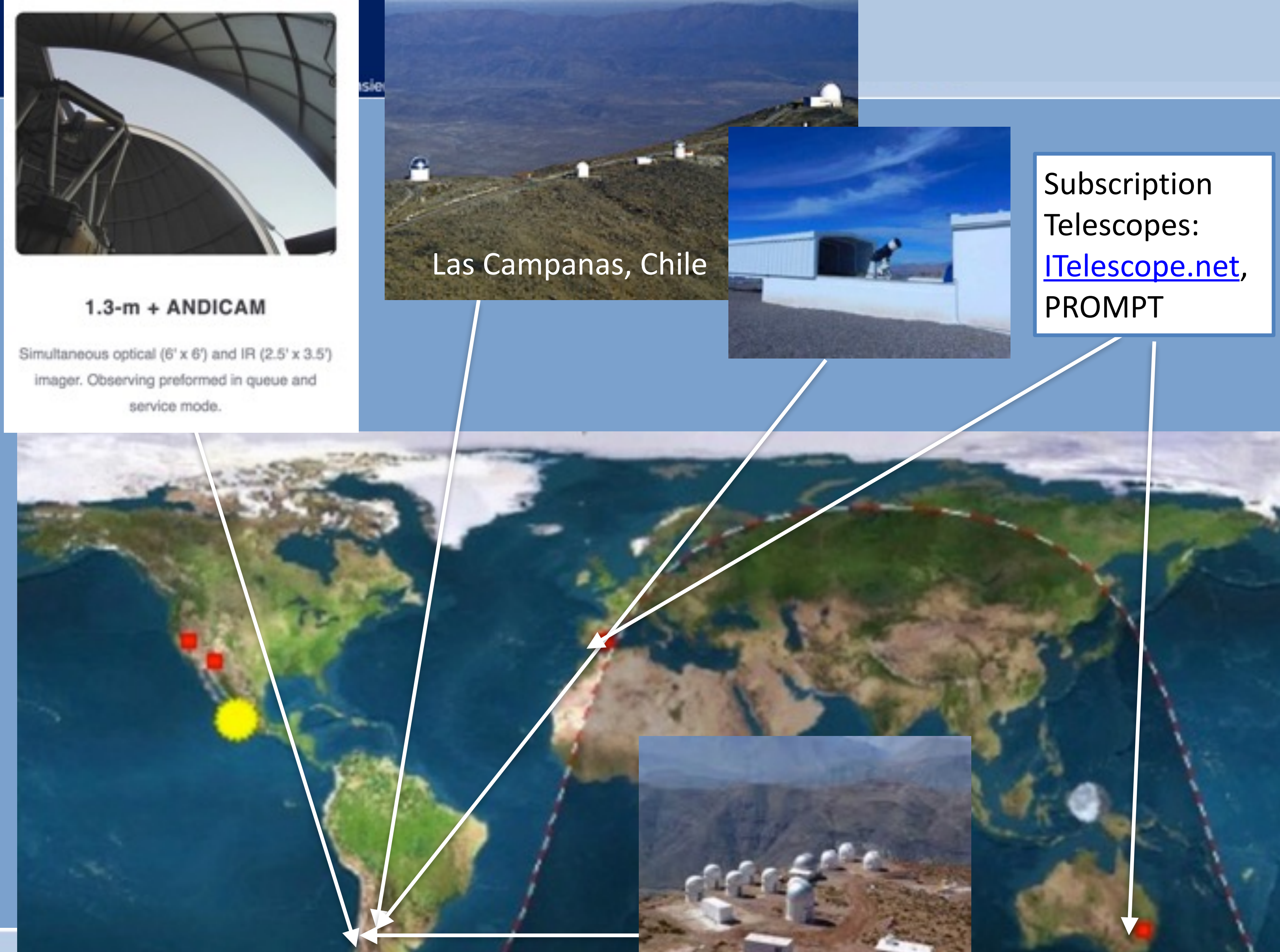
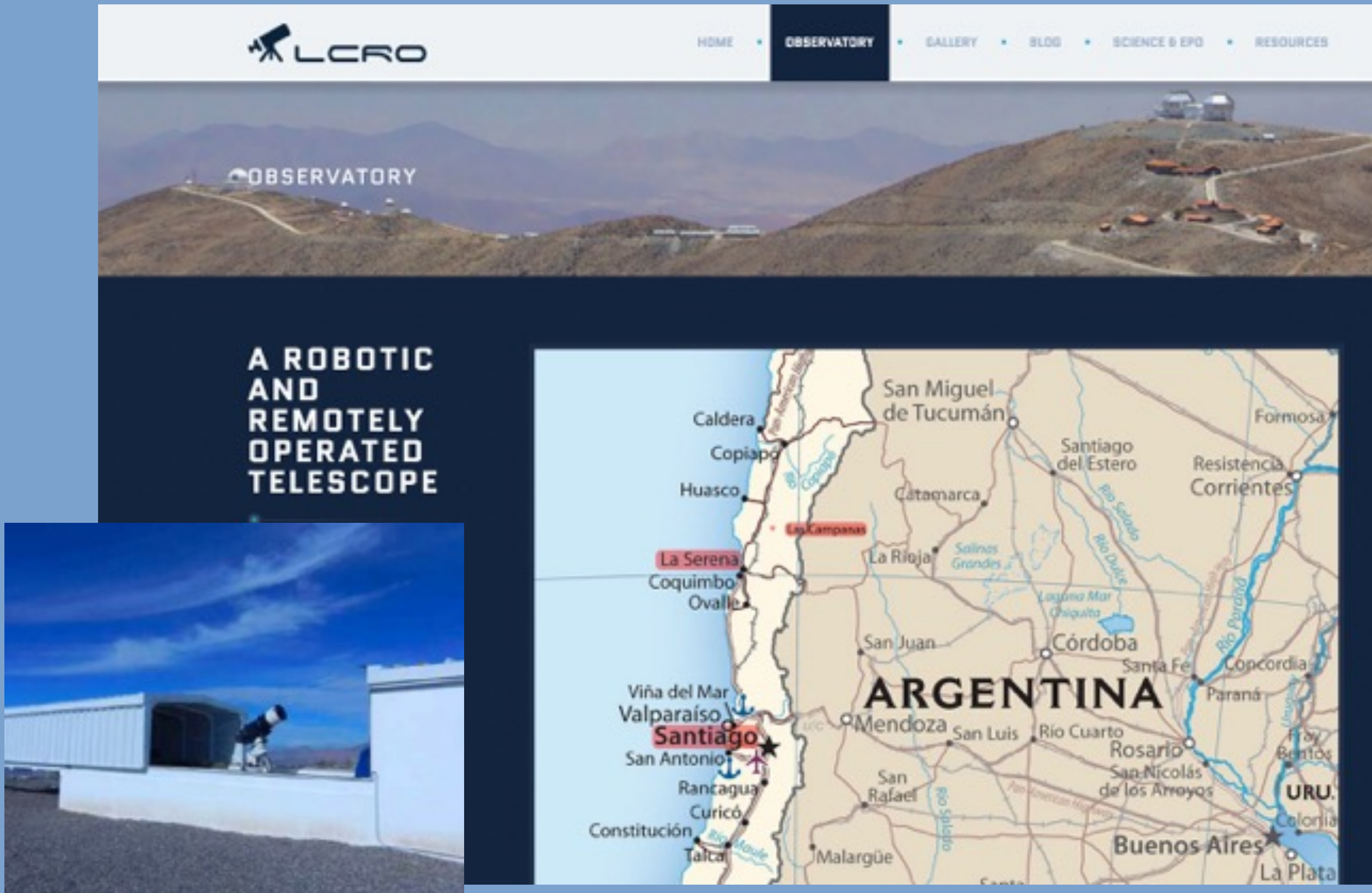


Remotely Operated Telescopes

LCRO - Las Campanas Remote Observatory



LCRO - Las Campanas Remote Observatory

55 arcmin FOV, 0.7” pixels, typical seeing - 0.5-0.7 arcseconds!

LCRO is a completely robotic telescope that can be operated remotely from any location with internet access using a web browser. The optical system includes the following.

Instruments

Telescope:	305 mm Makutsov Cassegrain F/8 from Astro Physics.
Mount:	Astro Physics model 1600 GTO.
Main Camera:	CCD from Finger Lakes Instruments (FLI) PL 16803.
Filters:	FLI model CFW-3-10 filter wheel containing Astrodon L, R, G, B, H-alpha, O-III, S-II and Sloan g', r', i'.
Focuser:	Finger Lakes Instrument Atlas model.

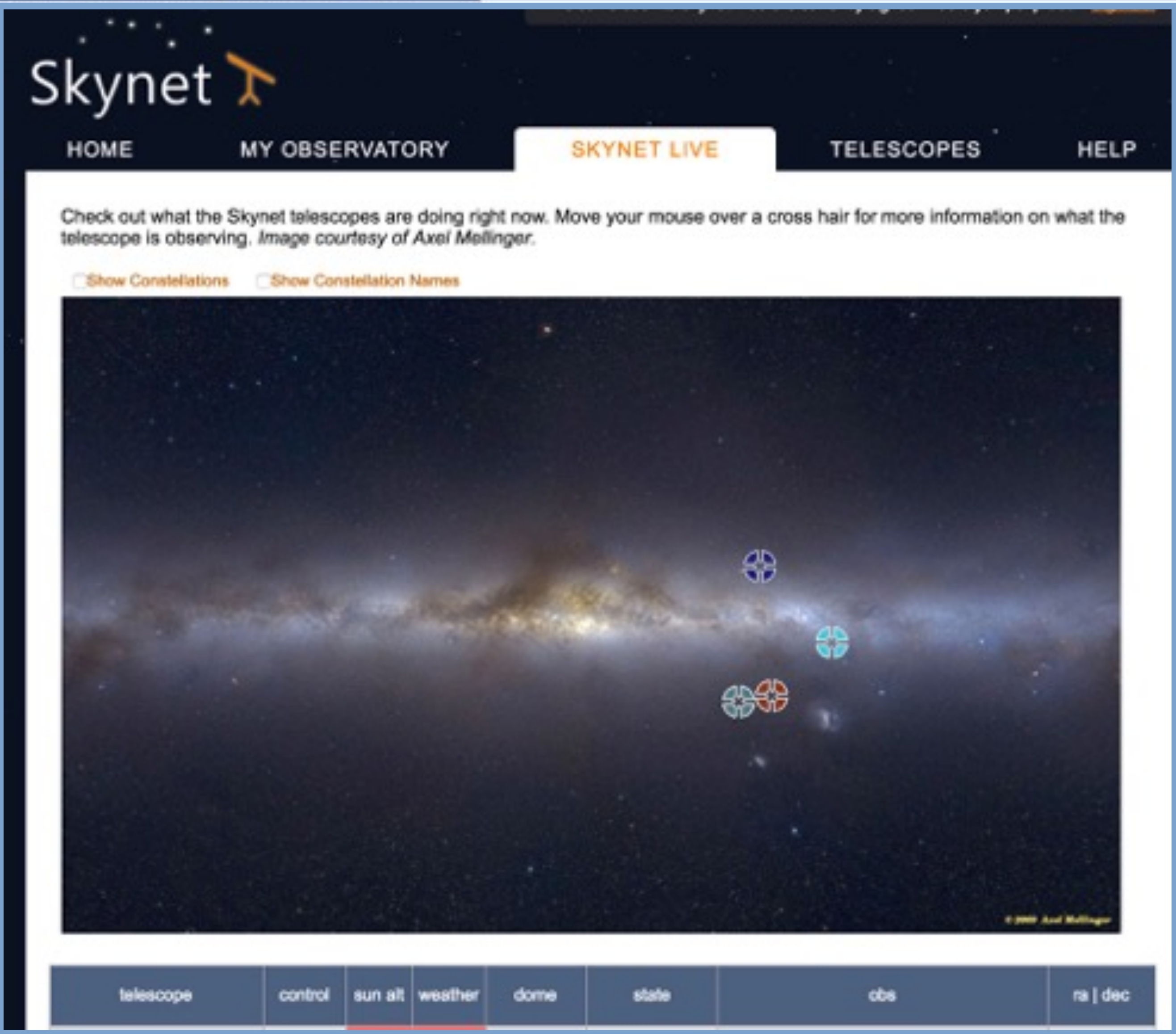
LCRO - Las Campanas Remote Observatory

Sample Images from LCRO - taken by Gabi Mehta, GROWTH undergraduate fellow this summer!

M83

Lagoon Nebula

Skynet - UNC Prompt Telescopes (CTIO, SSO)



Skynet - UNC Prompt Telescopes (CTIO, SSO)

	PROMPT-SSO-1 (offline) **Site:** Siding Springs Observatory **Location:** Coonabarabran, Australia **Filters:** Lum, Red, Green, Blue, uprime, gprime, rprime, iprime, zprime, B, V, R, I, Halpha, OIII, Exop, Clear, **Generic Filters:** HiThru, LoThru, GenR, GenG, GenB	Optical -31.3°	n/a n/a
	PROMPT-SSO-2 (offline) **Site:** Siding Springs Observatory **Location:** Coonabarabran, Australia **Filters:** Lum, Red, Green, Blue, uprime, gprime, rprime, iprime, zprime, B, V, R, I, Halpha, OIII, Exop, Clear, **Generic Filters:** HiThru, LoThru, GenR, GenG, GenB	Optical -31.3°	n/a n/a
	PROMPT-SSO-3 (offline) **Site:** Siding Springs Observatory **Location:** Coonabarabran, Australia **Filters:** Lum, Red, Green, Blue, gprime, rprime, iprime, zprime, U, B, V, R, I, Halpha, SII, Exop, Clear, **Generic Filters:** HiThru, LoThru, GenR, GenG, GenB	Optical -31.3°	n/a n/a
	PROMPT-SSO-4 (offline) **Site:** Siding Springs Observatory **Location:** Coonabarabran, Australia **Filters:** Lum, Red, Green, Blue, gprime, rprime, iprime, zprime, U, B, V, R, I, Halpha, SII, Exop, Clear, **Generic Filters:** HiThru, LoThru, GenR, GenG, GenB	Optical -31.3°	n/a n/a

Skynet - UNC Prompt Telescopes (CTIO, SSO)

	**Prompt2** (offline) **Site:** Cerro Tololo Inter-American Observatory **Location:** La Serena, Chile **Filters:** Red, Green, Blue, Lum, Halpha, OIII, SII, **Generic Filters:** HiThru, LoThru, GenR, GenG, GenB	Optical -30.2°	n/a n/a
	**Prompt3** (online) **Site:** Cerro Tololo Inter-American Observatory **Location:** La Serena, Chile **Filters:** SII, Lum, Red, Green, Blue, uprime, gprime, rprime, iprime, zprime, Clear, SPEC200, **Generic Filters:** HiThru, LoThru, GenR, GenG, GenB	Optical -30.2°	n/a n/a
	**Prompt5** (online) **Site:** Cerro Tololo Inter-American Observatory **Location:** La Serena, Chile **Filters:** Clear, U, B, V, R, I, gprime, rprime, iprime, zprime, Lum, Red, Green, Blue, Halpha, OIII, Open, **Generic Filters:** HiThru, LoThru, GenR, GenG, GenB	Optical -30.2°	n/a n/a
	**Prompt7** (offline) **Site:** Cerro Tololo Inter-American Observatory **Location:** La Serena, Chile **Filters:** Lum, Red, Green, Blue, Halpha, OIII, SII **Generic Filters:** HiThru, LoThru, GenR, GenG, GenB	Optical -30.2°	n/a n/a
	**Prompt8** (online) **Site:** Cerro Tololo Inter-American Observatory **Location:** La Serena, Chile **Filters:** B, V, R, I, Lum, Red, Green, Blue, Halpha, SII, OIII, Clear, **Generic Filters:** HiThru, LoThru, GenR, GenG, GenB	Optical -30.2°	n/a n/a

Skynet - UNC Prompt Telescopes (CTIO, SSO)

Optical Radio

GreenBank-20 (offline)

Site: National Radio Astronomy Observatory

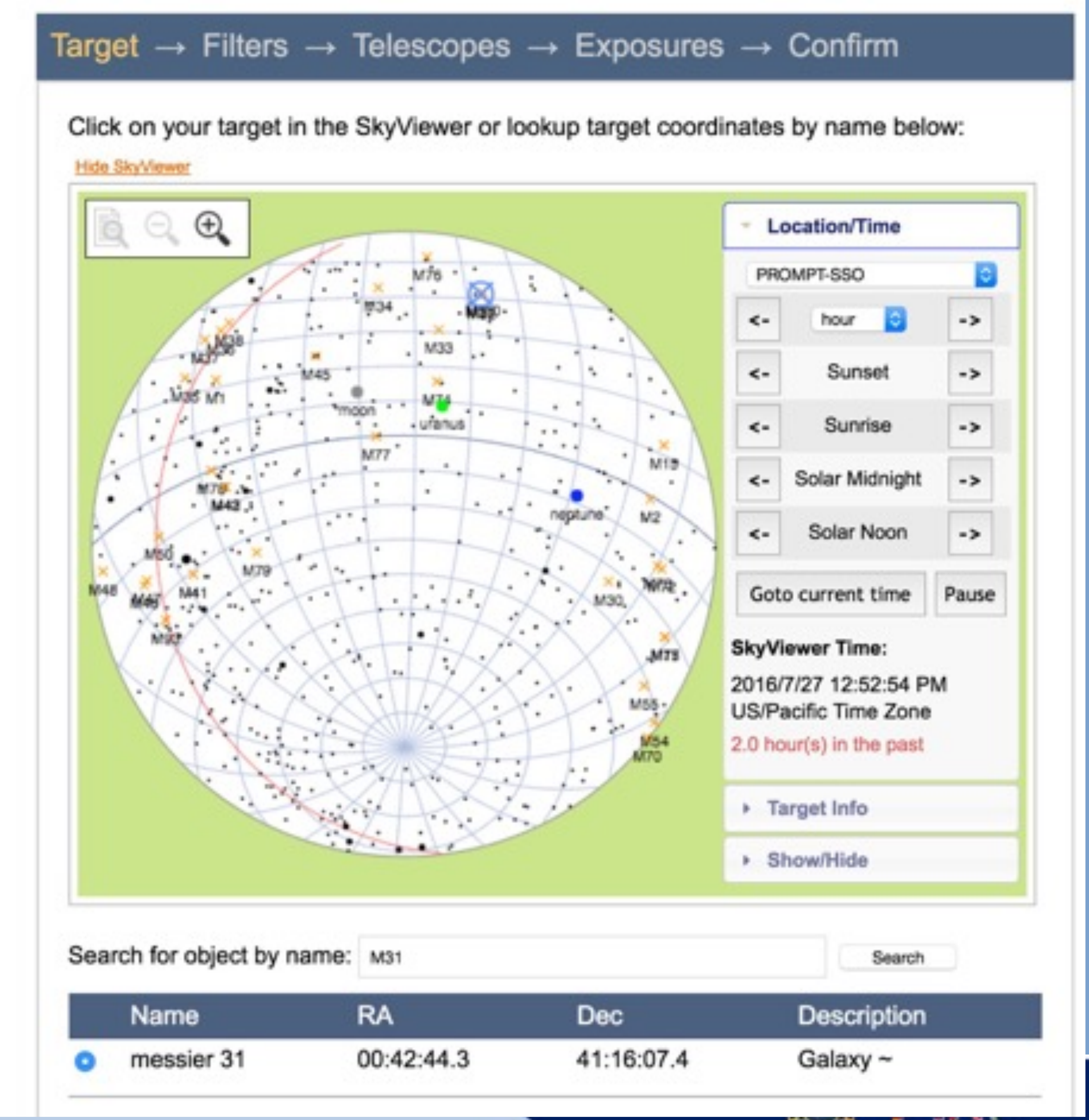
Location: Green Bank, West Virginia USA

Filters: N/A

Generic Filters: N/A

latitude	n/a
Optical	n/a
38.4°	n/a

Skynet - UNC Prompt Telescopes (CTIO, SSO)

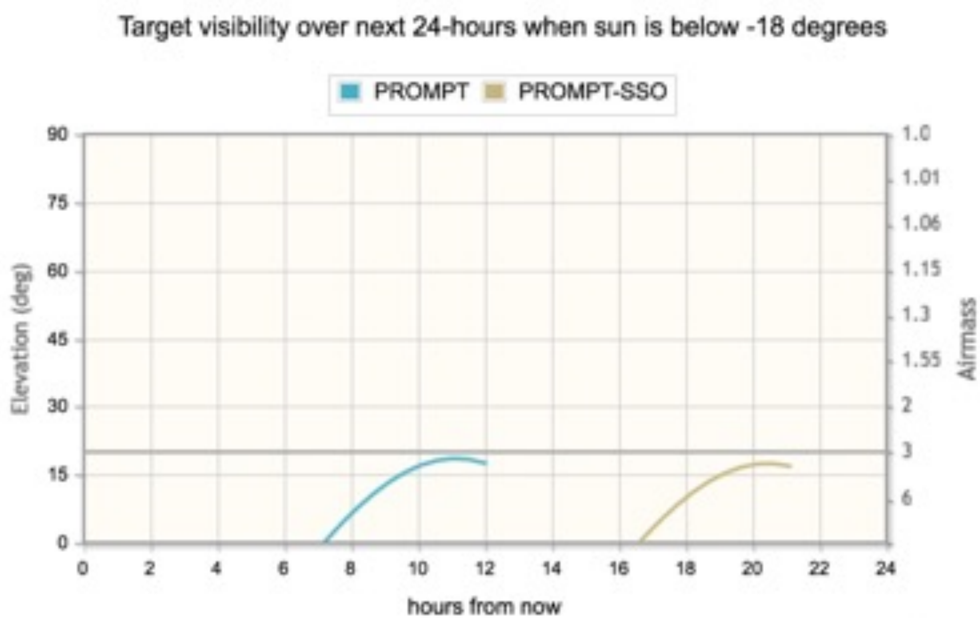


Search for object by name: M31 [Search]

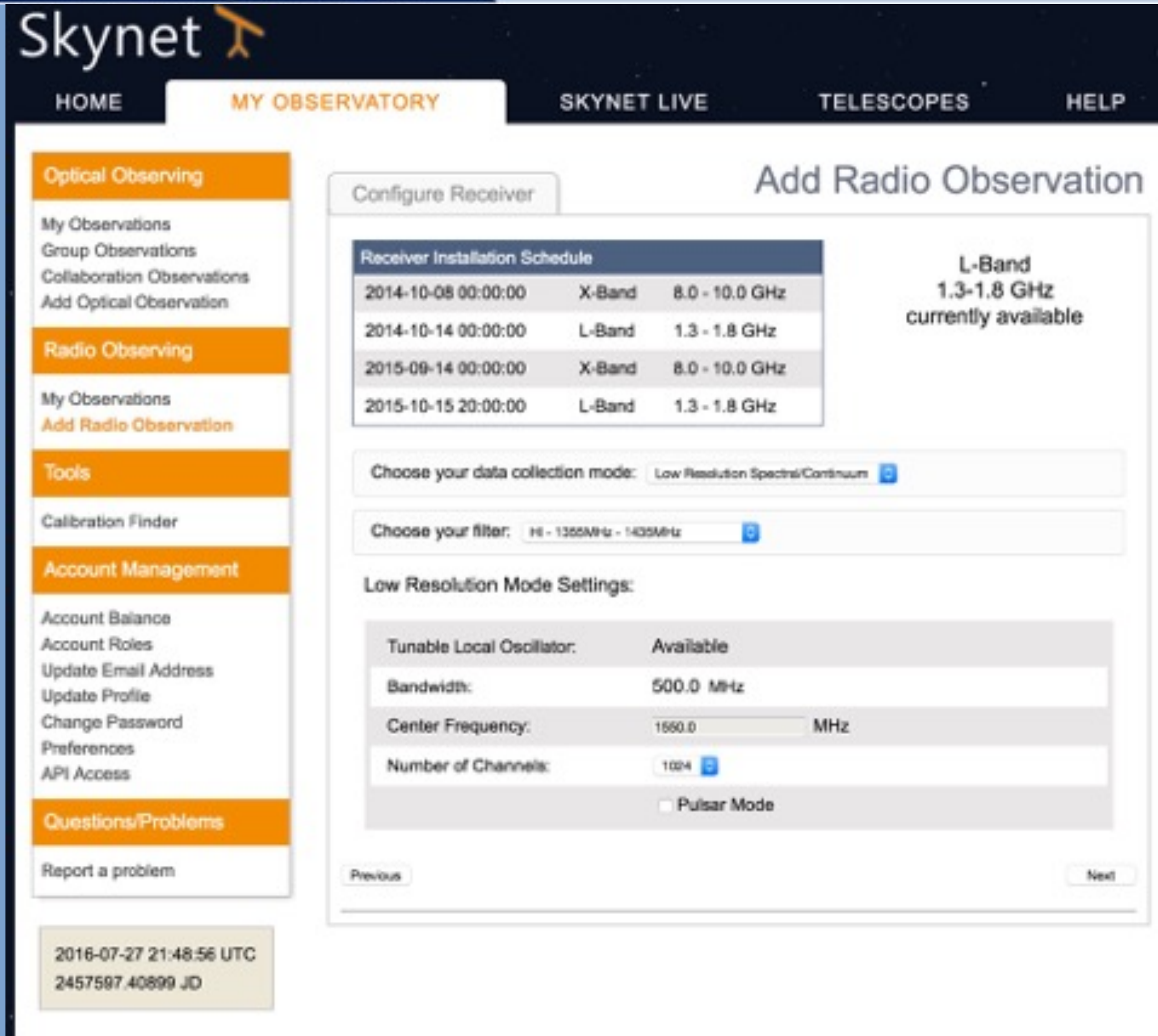
Name	RA	Dec	Description
messier 31	00:42:44.3	41:16:07.4	Galaxy ~

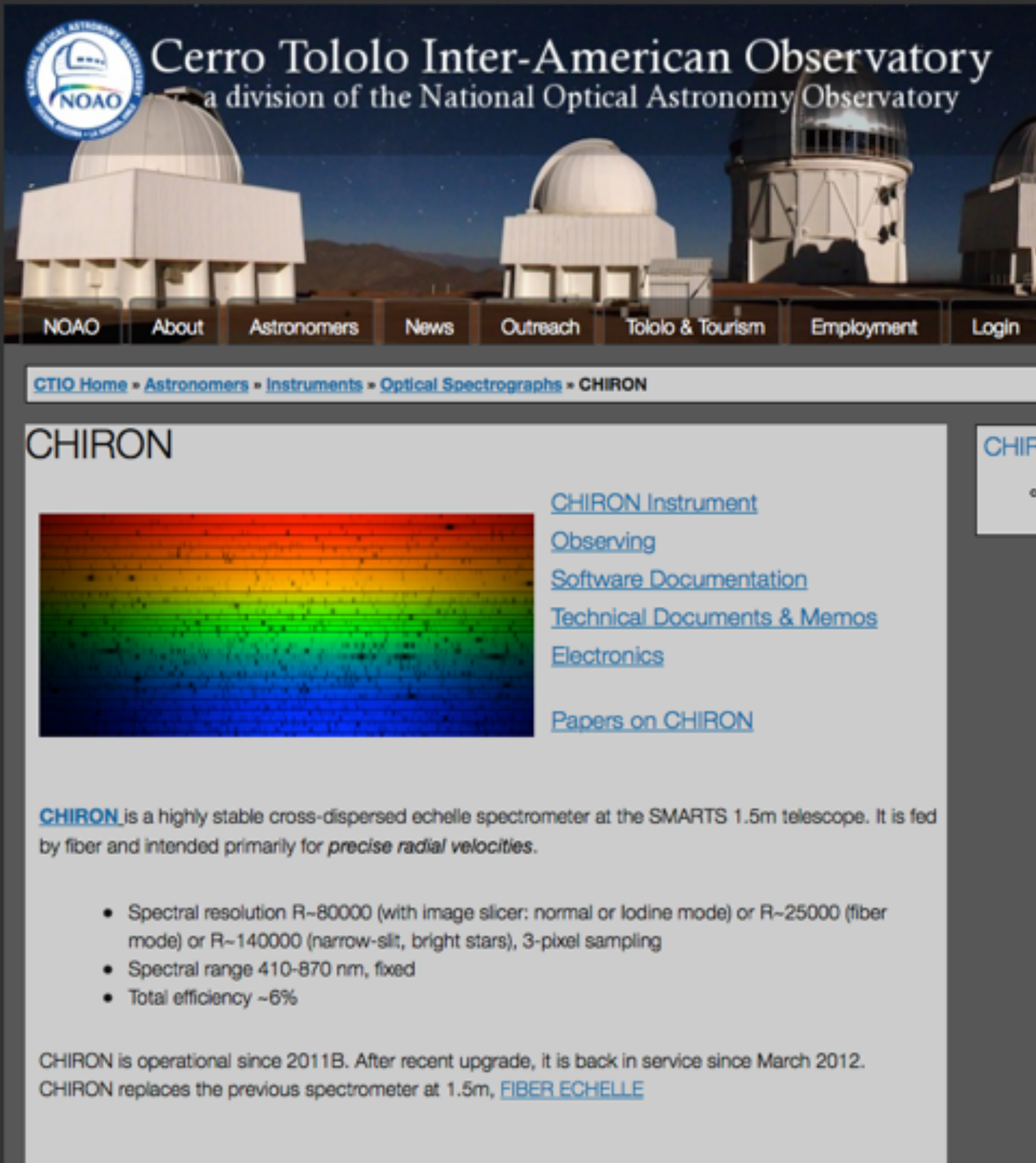
Observation Name:	messier 31	
Right Ascension:	00:42:44.3	hours (J2000.0)
Declination:	41:16:07.4	degrees (J2000.0)
Min Telescope Elevation:	20.0	degrees
Max Sun Elevation:	-18	degrees
Target must be observable for longer than	1.0	hours each night.
What would you like to do next?	choose the filters then pick the telescope	

(+) Show Advanced Settings



Skynet - UNC Prompt Telescopes (CTIO, SSO)





Yale-NUS Telescope Resources:

- 0.12-meter Celestron Telescope
- Celestron Imager
- Binoculars
- Yale-NUS Time on SMARTs CTIO telescopes!

Yale-NUS College Telescopes - SMARTS

SMARTS 1.3m telescope

About the 1.3m telescope

The 1.3-m telescope was previously the 2MASS southern telescope before SMARTS took over its operation. A permanently-mounted, dual-channel, optical-IR imager called ANDICAM takes simultaneous optical and infrared data on the SMARTS 1.3-m telescope. The 1.3-m is operated entirely in service / queue mode.

ANDICAM has been in regular operations at the 1.3-m since February 2003 by the SMARTS Consortium. Previously, it had been operated in queue mode on the 1.0-m (YALO Consortium) with the optical detector since the 1998B semester. The IR array was installed in July 1999. ANDICAM was constructed by the Ohio State astronomical instrumentation group led by Darren DePoy and its construction was funded in part by the National Science Foundation.

ANDICAM takes simultaneous optical and infrared data by using a dichroic with a CCD and a HgCdTe array. A moveable mirror allows dithering in the IR while an optical exposure is going on. ANDICAM is operated by the Prospero control software. It also has a twin--DANDICAM (Dutch ANDICAM)--that is used on a 1m telescope in South Africa. With ANDICAM one can obtain UBVRIJHK photometry within a 6 arcmin (optical) or 1 arcmin (near-IR) field.

ANDICAM Resources

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For our GROWTH Educational Effort

What are some of the telescopes you might operate?
Can they be shared with remote observers?

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An LCRO Astronomy Curriculum - Developing Student Researchers in an Astronomy Class Using a Remote Telescope at Las Campanas, Chile

A proposed curriculum by Bryan E. Penprase
Professor of Science, Yale-NUS College, Singapore
Research Professor, Pomona College, Claremont CA

Overview: Our goal is to provide an unprecedented richness of experience for undergraduate astronomy students that prepares them as realistically as possible to become research-capable astronomers. This effort is also unique in that as it is scaled up, every effort will be made to preserve the immediacy of the observing experience. The course has the larger goal of not just training students to follow a "cook book" and operate a telescope, but to train students to become scientists. This formulation requires students to progress through three phases in their development, and each of these three phases are described below. The final stage is to have students who can progress to a cognitive level known as "expert thinking" where they are able to apply their knowledge of both the technology and the abstract subject knowledge of astronomy toward creating an investigation in which they identify a research question, develop a strategy for answering this research question with the telescope and instrument, and then implement this research project, with a final stage of writing up the project in a forum that includes review by the students' peers.

Labs and Telescope Time needed: The curriculum described below is designed along a 10 week schedule to be available to institutions that have either quarter or semester terms. The duration of each of the segments can also be lengthened if necessary to fill an entire semester, depending on the preparation and ability of the students. The lab requirement for this class includes six labs, and only three of the labs require the entire class to be present at the same time, lessening the load on instructors and facilities.

The labs and telescope time needed is summarized below:

LAB1: **Experiencing the Sky Outside.** (needs small telescopes + either dome planetarium or desktop planetarium program)
LAB2: LCRO Orientation and Intro to the Sky in Chile. (needs 1/2 or 1 night; best with two telescopes both controlled "live" with students)
LAB3: **Photometry with CCDs.** (needs 1 night; again best with two telescopes both controlled live with students)
LAB4: Tricolor Imaging of Extended Objects. (needs 2 nights; this can be conducted in queue mode)
LAB5: Generating a Scientific Dataset. (needs 2 nights spread over two weeks; expect that some student teams will "fail". Provide 1 night for makeup).
LAB6: Design and Implementation of Student research Projects. (needs 2 nights each week for 4 weeks).

Total telescope time needed for class -> 15 nights.

Overview of the Curriculum, with Phases of Cognitive Development

PHASE 1: Awareness of the sky and telepresence in Chile

Week 1: Telescopes, Stars and the Sky. Classes 1&2: Students go through an introductory pair of lectures on telescopes and stars, and the basic parameters of the sky - astronomical coordinates, alt az and equatorial coordinates, airmass, and constellations. This is followed by a planetarium session and a hands-on session outside with small telescopes.

LAB1: Experiencing the Sky Outside. Students view the current sky in planetarium, and go outside to locate stars in the sky, and their positions, sidereal times, and coordinates are noted. Students identify constellations and major planets. Eyepiece observations of these are conducted to make them "real" on a sensory level.

Week 2: Observatories and Instruments in Chile. Classes 3&4: Students are giving a tour of the country of Chile via satellite using Google Earth. They are given a brief history of the observatories in Chile, and the unique capabilities of the telescopes and the properties of the sites within Chile. This tour of the country zooms up onto the major observatories of Chile - ESO La Silla, VLT, ALMA, CTIO, and Las Campanas, and gives an overview of the different telescopes found there. Students each take on one

LAB2: LCRO Orientation and Intro to the Sky in Chile. For the first LCRO lab, students zoom into the site via google earth, and are given a thorough tour of the Las Campanas site with something akin to Google's "on the ground" where they can move around and see the site. A set of live web cams and weather stations are viewed to get a thorough assessment of the site conditions. Ideally, a person on site is available by Skype to talk with the students and "tour" one area of the mountain or the little telescope and the region around it.

As night falls, students then are given a tour of the little telescope, and one of the students opens the dome. Audio and video of the site and student-activated commands convince students that they are in control, thousands of miles away. This is stressed and multiple students are abel to take control of the telescope and move it around to a view on video cameras.

Rather than just take CCD images, this phase includes students checking on planetarium programs or going outside to view planets and moon and bright stars that are in the sky now, and then checking with the telescope to see these same stars. Differences are noted - orientation and location on the horizon - compared to current location. They are asked to take short exposures of the objects that they were able to see in the telescope session of LAB1, and also some additional objects that are not visible from their location. Students are asked to make a gallery of planet images, and to experiment with making them into "tricolor" images for the lab writeup. This first observing with LCRO is done "live" - with preview images showing on the monitor in Chile and a script automatically updating and displaying the most recent image on a screen that is shared with the class.

PHASE 2: Making vision real - Imaging and Camera Control

Week 3: Measuring Light - Stellar Photometry, CCD detectors, and SEDs. Classes 4&5: Students learn about magnitudes, CCDs, stars, and the MK classification system. Spectra of stars, and the relationship between spectra and photometry is stressed with apps in class (the NAAP applets are particularly good), and some hands-on spectroscopy exercises. In-class calculations build toward the analysis that will be done in LAB3.

LAB3: Photometry with CCDs. With the first images taken, students advance to a second stage of awareness of the telescope as a set of "eyes" that can see the sky. Students go through an initial check-out that includes planets that are visible, moon and a sample of bright stars spanning the MK spectral types. Students verify the effects of varying observing time, and the result on images. The notion of saturation is

LAB4: Tricolor Imaging of Extended Objects. For the fourth lab, students will be asked to take “pretty pictures” of deep and extended objects. They will have to predict the size of the object, and its location with the CCD, and the exposure levels needed based on the magnitudes. A set of filters will be chosen to create a set of tricolor images that are both beautiful and reveal stellar populations with the object or emissions lines from nebulosity. A pre-observation mini-proposal will be asked for and checked before the observations. These observations will be put into a queue/script and students will be asked to do this task and run this script in teams that each will cover a half night. Two nights are used for the class “gallery” of images.

PHASE 3: Creating a Research Question, and Developing a Program for Answering with Data

Week 5: Generating a Scientific Dataset. Classes 8&9: Students will be asked to choose one of four teams - exoplanets, variable stars, stellar populations, and galaxies. Each team will develop a plan for a research project to be conducted as a group. Class time will be used to consult with the students, review literature and give a class overview of the scientific background for each team. Again the class will be asked to create a mini-proposal that will describe their target, the best time for observation (taking into account visibility and moon), and the exposure level and filter sets needed. Two nights will be needed to execute this project and to write up the findings. The findings will include a team-generated light curve for an exoplanet, a periodogram and phased light curve for a variable star, and HR diagram for the star cluster, or some

LAB5: Team-based Scientific Observing. Again in queue mode - students generate scripts and supervise observing as teams. Each team is given 1/2 night.

Week 6: Presentations by Teams. Classes 10&11: Students will analyze and present their findings to the class. One session for data analysis and consultation, and one for presentations.

Week 7: Final projects - Developing and Implementing a Research Program. - students will generate a research project in consultation with instructor. They will prepare an observing proposal for this project and then execute the project. The observing proposals will be required to be submitted by the end of the week and will be graded as 1/3 of their project grade.

LAB6: Design and Implementation of Student research Projects. Here we award each student about 1/2 night, so this will take something like a week of observing time, spread out over several weeks. Students will be schedule a block of observing time based on their proposal and be asked to conduct their own observations.

Week 9: Future of Astronomy and Current Controversies - Open questions and controversies of current astronomy research are presented and discussed in class.

Week 10: Presentations of Results. Students each give short talk 10-15 minutes on their work. This spreads out over 6 per class and about 3 classes.

Week 11: Written presentations are uploaded to site, and reviewed by class and larger peer community.

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Parallel Global Observational Astronomy Course - Possible Weekly Schedule

Week 1	Week 2	Week 3	Week 4	Weeks 5+6	Week 7
Telescope Design, CCD detectors, Astronomical Coordinates	Astrometry Exercise (parallax or orbit determination)	Basic Photometry (measurement of HR diagram)	Time-Domain Photometry - light curve + periodogram	Submit Proposals for student projects + conduct observing	Presentations and writeups of student work
Begin Project - within semester or quarter	Students at multiple campuses can provide parallax data, share orbit data	Professors can share tutorials, and students can pool data for photometry	Multiple student groups can provide 24-hour coverage of time-variable sources	Global student research community can share data analysis tips and telescope time	

Discussion -

What is a better timeline for this course?
How long should these units take?
What other units need to be included in an observational astronomy course?

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Next Steps!

What can you adapt?
What can you adopt?
What can you contribute?

Dinner!
6:00PM